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Status of the CCDs sensors for DAMIC/DAMIC-M

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Recent advances in CCD technology due to the increase in the purity of the silicon have allowed the fabrication of thicker devices, achieving a record thickness of 675 microns with an area of 6cm x 6cm, for a CCD mass of 5.8 g. This opens up a new experimental frontier in searching for coherent scattering of dark matter or neutrinos from silicon nuclei that produce ionisation energies of only 10s of electron Volts.
Furthermore, these CCDs also present high spatial resolution and an excellent energy response in very effective background identification techniques. This has been the idea of the DAMIC detector located at SNOLAB, taking data since 2017. The charge resolution with such a low electronic noise (approx. 2 e-) allows an unprecedentedly low energy threshold of a few tens of eV (40eV), dominated by the noise of the readout amplifier. The extremely low leakage current is the lowest dark current ever measured in a silicon detector, <10-21 A/cm2 at an operating temperature of 105 K [38], exquisite spatial resolution and 3D reconstruction. A truly unique capability of DAMIC is that background can be identified and rejected as spatially correlated events occurring at different times. Hence, DAMIC has the ability to distinguish radiogenic backgrounds such as alphas, betas, muons, etc. This imaging capability of the CCDs allows to observe ¨in situ¨ disintegration chains like 238U, 232Th, 32Si, etc. These characteristics make the DAMIC CCDs a well-suited detector to identify and suppress radioactive backgrounds and search for Dark matter candidates.
The collaborations is planning to increase to 1kg of CCD cameras in the next three years in the Laboratoire Souterrain de Modane (CNRS / Université Grenoble Alpes). The DAMIC-M CCDs will be 6k x 6k pixel sensors with a skipper-CCD, a breakthrough technology with unprecedented sensitivity for ultralow-energy particle detection, with repetitive, nondestructive readout of a a thick, fully depleted charge-coupled device. DAMIC-M will achieve a noise level of less than 0.1 e rms/pixel. Such a low noise readout and a dark current below 10-21 A/cm2 will enable a threshold of 2 or 3 electrons (corresponding to DM energy transfers as low as ≈ 3 eV given the silicon band gap energy). DAMIC-M will feature the most massive CCDs ever built. With this unprecedented sensitivity, DAMIC-M will take a leap forward of several orders of magnitude in the exploration of the dark matter particle hypothesis,DAMIC-M, will pioneer the low-mass DM searches with unprecedented sensitivity to DM-electron scattering and hidden-photon DM, by improving by orders of magnitude the sensitivity to the ionisation signals from the scattering of dark matter particles with valence electrons.

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